THE LOCALIZATION OF THE REFLEX MECHANISM.*

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The study of the reflexes in complete lesion of the cord is of interest both on account of its value in diagnosis and pathology, and on account of its bearing upon the localization of the reflex mechanism. The present tendency in favor of cerebral reflex centers is largely due to Bastian's observation that the knee-jerk is abolished by complete transverse lesion, an observation which may have to be modified by the experiences of Brissaud, Raymond and Cestan, which seem to indicate that gradual destruction of the cord, even though complete, may give rise to spastic paralysis. But acceptance of cerebral reflex centers does not quite in itself solve the problem. In fact, the reflex conditions found in disease are too varied to be explained on the basis of single centers, whether cerebral or spinal. It seems probable that we shall be forced to assume, with Grasset, that there are in man at least three regions, namely, spinal, basilar and cortical, all of which are possessed of centers for tonicity and reflex, all normally in play in the healthy adult, the higher supplementing and controlling the lower more and more as the animal scale is ascended, though not absolutely replacing them as claimed by Crocq. If this is true, the lower centers in the healthy human adult may remain comparatively, or quite, quiescent, while the higher are in the full exercise of their sway; but when the control of the higher centers is interrupted by disease, it may well be that the lower centers resume their activity, and with increasing force, through lack of cerebral influence.

An analogous condition is found in the vaso-motor control. If the lumbar region is cut off from the bulbar vasomotor centers the blood vessels of the lower extremities dilate, and the superficial temperature is raised. In the course of time the vessels resume their tone, and the normal temperature is restored. Physiologists explain this phenomenon, when produced experimentally in lower animals, by supposing that rudimentary, or at least inactive, vaso-motor centers in the cord, take up their function only when the bulbar centers become ineffective, and there is no reason to doubt that a similar, though perhaps more complicated, process takes place in the human being.

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Among the apparently contradictory propositions whose reconciliation is impossible on the supposition of single centers, and difficult even with the aid of multiple centers, may be found the following, some of which are established, while others require further verification.

(1) In cerebral hemorrhage the paralysis may be at first flaccid, and the reflexes abolished (Dana and others).

(2) If the connection between the brain and the lumbar cord is permanently severed, the knee-jerk does not return (Bastian and others), but the plantar reflex may return (Fränkel).

(3) If the destruction of the upper cord is gradual, the knee-jerk does not disappear but becomes exaggerated (Brissaud).

(4) If pyramidal transmission is reëstablished, the knee-jerk returns, and under certain circumstances is exaggerated; the cutaneous reflexes (unless the Babinski is deemed a cutaneous reflex) are diminished if the patient is an adult, preserved, if a young person.

(5) The Babinski reflex may appear at the onset of high lesion during the period of flaccidity and absence of all other reflexes (Stewart and Turner, Walton and Paul).

(6) In earliest infancy, even in infants prematurely born, extensive reflex movements of the feet and toes are present. (The fact that some observers find in these movements a Babinski reflex, and that others find them indeterminate, with perhaps a predominance of extension and separation of the toes, adds another complication to the problem.)

(7) These reflex movements of infancy are gradually replaced, probably after two years (Morse) by the constant flexor reflex of adult life.

(8) The cremasteric reflex is established in early infancy, (though its systematic test at this age is rendered difficult by the mechanical conditions, particularly the non-emergence of the testicle). This reflex becomes very active in early life, and is later replaced by, or modified to, the normal adult reflex.

(9) The knee-jerk is very active in infancy. (In infants I have recently examined with reference to this discussion, through the kindness of Drs. Richardson, Rotch and Green, I have found that the knee-jerk is difficult or impossible to elicit in prematurely born infants, and sometimes difficult to elicit at full term. I have generally been able to obtain it, however, in the first few days of life, and have found it steadily increasing in activity, and becoming very active, at, for example, eighteen months. This reflex is best obtained in infants by holding the thigh at right angles with the trunk and supporting the lower leg in the hand, at right angles with the thigh. The tap is best made very near the patella with a small rubber percussion hammer.)

Can these, and other, observations be reconciled with the supposition of single centers, either in the cord or in the brain? No. If, for example, a center for the knee-jerk exists in the cord alone, why is the knee-jerk permanently lost when the cord is suddenly severed from the brain? Even the fact that it is temporarily lost under these circumstances is not readily explained on the assumption of simple spinal centers. The theory of shock, as maintained by Gowers, leaves much to be desired. The objection of Stewart and Turner is well taken, that such shock should also restrain the Babinski reflex, which appeared, for example, in their case of spinal fracture on the day of the accident, while the knee-jerk was abolished for two weeks.

If a center for tendon reflexes exists in the brain alone, why should the knee-jerk be always exaggerated when the connection with the cord is reëstablished, even though that connection is a faulty one? Crocq's supposition that irritation of the pyramidal fibers under these circumstances adds to the reflex irritability of the basilar centers, is vague and unsatisfactory. It would be strange if pyramidal fibers not sufficiently conductive to convey the least trace of voluntary motion, should readily transmit a heightened reflex stimulus. In the endeavor to explain the sluggish cutaneous reflexes sometimes coexisting with exaggerated tendon reflexes he assumes that the same pyramidal irritation which increases the activity of the basilar centers, inhibits that of the the cortical centers, an assumption which shows the arbitrary nature of his theory.

With regard to the cutaneous reflexes, if it is true that the plantar reflex can appear when the cord is completely and permanently separated from the brain, there must be a center for this reflex in the cord, but there must be also a controlling center for this reflex in the brain, or it would not be even temporarily abolished by cerebral disease, or by fracture of the spine.

The attempt to explain the varied conditions is not altogether satisfactory even with the assistance of multiple centers, but it may proceed perhaps somewhat on these lines: Let us suppose with Crocq that in the human adult the controlling centers for cutaneous reflex and for muscular tonicity, have risen to the cortex, and that those for the knee-jerk have risen to the basilar region. But let us modify this theory by that of Grasset, that the lower centers, meantime, have not entirely resigned their function. May not a key to the most serious difficulty (namely, the varying predominance of the tendon and the cutaneous reflexes) be found in the following considerations? (a) Since the centers for the skin reflexes have reached a higher plane, their lowest centers (the spinal) will be less readily reëducated than those of the tendon reflexes, whose controlling centers have risen only to the basilar region. (b) Since the tendon reflexes require a certain degree and balance of muscular tonicity, they may sometimes, in default of this quality, be outstripped by the cutaneous reflexes, for which tonicity is a matter of secondary importance.

In infancy the reflex movements of the toes are of spinal origin, before the permanent normal relations with the brain are established. After these relations are established the higher centers preside over, and maintain, the normal cutaneous reflexes of adult life, the spinal centers meantime becoming inactive, more inactive, perhaps, than the spinal tendon reflex centers, since the cutaneous reflex mechanism has reached the higher plane. If the cerebral connection has been injured, with partial reëstablishment, the cutaneous reflexes disappear until the spinal centers resume their function, which they are able to do actively if the patient is young, but sluggishly, if at all, if he be an adult. The appearance of the Babinski in adult life under these circumstances must be regarded, not as an exaggeration of the normal plantar reflex, but as a peculiar reflex, present only under pathological conditions. The fact that the Babinski appears more promptly than the exaggerated knee-jerk, and even sometimes when no knee-jerk is present, must be explained by the fact that no special adjustment of muscular tonicity is required for its production, and by the probability that its controlling center is spinal, and that its nature is so elementary that it is ready, like the active reflexes of the frog, to spring into existence immediately upon the withdrawal of cerebral control. The active reflex movements of the feet and toes at or before full term, and the persistence of the plantar reflex in case of permanent complete transverse lesion of the cord, may be similarly explained.

The same arguments can be followed with the knee-jerk up to a certain point: if the knee-jerk is temporarily lost, as in case of apoplexy or of spinal fracture, it is because the cerebral reflex center is rendered ineffective either by direct injury or by its functional separation from the lumbar region. In this event the knee-jerk returns, and becomes exaggerated, because the spinal centers now become active, and abnormally so, resuming, without inhibition, a function hitherto in abeyance.

The point of divergence of the knee-jerk from the plantar reflex appears first in case of sudden, complete severance of the cord. In this case the knee-jerk does not return, but it would appear that the plantar reflex may do so. The other point of divergence is in the newly-born, particularly the prematurely-born infant, in which the knee-jerk is faint or wanting, while the cutaneous reflex movements are active. These two peculiarities might lead to the inference that there are no centers in the cord for the knee-jerk, but they do not necessarily establish that proposition for this reason: in order to elicit the knee-jerk a certain degree of tendon stretching as well as a certain degree of muscular tonicity is essential, and even a certain balance of tonicity must exist between the flexor and extensor group of muscles, and even then the knee-jerk is aided by reinforcement (whether this procedure acts by increasing the muscular tonicity without altering its balance, or whether it acts by readjusting the control, for example, by withdrawing the inhibition of the highest cerebral centers). The permanent loss of knee-jerk in case of sudden severance of the cord may be due then, to the inability of the spinal centers for tonicity to resume their function before the muscles have lost their power to respond. That these conditions are sometimes reëstablished, namely, when the destructive process has been a slow one, is indicated by Brissaud's case of spastic paralysis in which a long segment of the cord had been reduced to a mere fibrous thread by tubercular process. Similarly, in the prematurely-born infant, the spinal centers for the knee-jerk may be unable to act until the cerebral centers control the tonicity. Hypertonicity, rather than lack of tonicity, may prevent the reflex at this period, since the spinal centers for tonicity are doubtless in force at this stage, their activity being evidenced by the tendency to rigid flexion of the limbs in the premature infant. Or perhaps hypertonicity of the flexor groups, according to the law of Crocq, inhibits the tonicity of their antagonists, the extensors. The absence of knee-jerk in certain cases of long-standing infantile cerebral hemiplegia or diplegia with contracture is doubtless due to similar cause. However this may be, it is probable that the spinal centers preside over the tendon reflex of early life, but are gradually overshadowed by cerebral control.

If it is true that complete transverse lesion, when of gradual onset, may produce spastic condition with increased knee-jerk, we must assume that the spinal centers of tonicity can gradually become reëducated during the time that the cerebral centers of tonicity are losing control.

The selection of certain regions in the brain as a basis for the line of analysis suggested in this somewhat sketchy discussion, is not intended to be final. We are hardly in position at present to attempt the exact localization of the neurones through which these stimuli pass. But whether, for example, the cerebellum plays the important part assigned it by Bastian, or whether the red nucleus and its descending fibers occupy a prominent place, as the studies of Collier, Buzzard, and others would indicate, it falls in line with the modern interpretation of the various cerebral functions to assume that the reflex mechanism has multiple relations. In fact, a simple change of base on the part of these centers from the cord to the brain, would imply that a mechanism only little more intricate than that which suffices for the elementary functions of the frog, is able to control the complicated reflexes of the human organism.